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RESULTS OF SARDINE DAILY EGG PRODUCTION OFF THE NORTHERN COAST OF SPAIN FOR APRIL 2008

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Abstract

This document presents the results of the SAREVA0408 ichthyoplankton survey conducted by IEO (Instituto Español de Oceanografía*)*. This survey was carried out on board R/V *Cornide de Saavedra* during April 2008. The covered area was the North and North-western Iberian Peninsula waters and the inner part of the Bay of Biscay (from 42°N to 45°N).The present paper includes data on sardine (*Sardina pilchardus)* egg distribution and abundance from the SAREVA0408 survey, as well as the estimation of daily egg production (DEPM) for sardine in the North Spanish Atlantic, Cantabrian waters and south of the Bay of Biscay.

Introduction

In order to provide an estimate of the spawning stock biomass of the Atlantic-Iberian sardine, different DEPM surveys have taken place in 2008 covering the area from the Gulf of Cadiz to the inner part of the Bay of Biscay (Atlantic-Iberian stock). The IEO carried out two combined surveys in April 2008, one for ichthyoplankton on board RV *Cornide de Saavedra* (SAREVA 0408) covering the Northwest and North of Iberian Peninsula and South of the Bay of Biscay (from 42ºN to 45ºN), and another for adults surveying on board RV *Thalassa* (PELACUS 0408) from 41ºN to 44ºN.

Surveys to assessment with traditional methods sardine resources in the same area have been carried out in years 1988, 1990, 1997 (Pérez et al., 1989; Garcia et al., 1991; Lago de Lanzós et al., 1998) and since 1999 (ICES 2000, ICES 2004, ICES 2006) at triennial period.

Egg production for Atlantic-Iberian sardine was estimated in three different ways in relation to development model to the incubation data i) the method developed by Lo (1985) ii) the Generalized model or Bayesian method (ICES 2004) iii) the extended Bayesian method or Multinomial model (Bernal et al., 2007). However, in the WGACEGGS (ICES, 2007) it was assumed that the best embryonic development model is the multinomial, since it is statistically the more correct.

As in previous years and for the purpose of comparison the Daily Egg Production of the North Spanish Atlantic was estimated. The Daily Egg Production of the French waters was estimated separately.

Material and methods

The ichthyoplankton survey (SAREVA 0408) was carried out on board R/V *Cornide de Saavedra* from 2nd to 27th April. A total of 530 samples were taken with a PAIROVET net (double CalVET), on 62 fixed transects perpendicular to the coast and spaced 8 nm. PAIROVET samples were taken every 3 nm in the inner shelf (up to 200 m depth) and every 3 or 6 nm beyond the inner shelf, depending on the egg abundance indicated on the CUFES (Continuous Underwater Fish Egg Sampler) samples. The CALVET hauls were performed using a 150 µm mesh size and fitted with flowmeters (General Oceanics), operating vertically (1 m/s) net from the sea surface to 100 m depth or 5 m above the bottom in shallow areas. Moreover, a CTD Seabird 37 was deployed every haul coupled to the PAIROVET net in order to obtain sample depth and salinity and temperature profiles and haul quality. To describe the oceanographic and meteorological character of the area, profiles of CTD (SBE 25) were made until 500 m maximum depth in alternate stations of icthyoplankton. Also, a continuous record of temperature and salinity (at 5 m depth) was obtained from a thermosalinometer during the survey.

In order to delimitate the spawning area of sardine a semiadaptative sampling with CUFES was developed, deciding to enlarge the radial in case the presence of eggs were found at the end of each radial. The outer transect limit was reached when two consecutive CUFES samples were negative beyond the 200 m depth. The CUFES sampling grid matched with CALVET sampling grid and was carried out simultaneously. A total of 511 samples were taken with CUFES. The CUFES sampler was equipped with a 335 µm mesh size net and the water intake was around 600 l/min. Sampling depth of CUFES was at 5m.

CUFES and CalVET plankton samples were preserved in formaldehyde 4% buffered with borax in fresh water. The CalVET samples from one cod-end were used for sardine egg quantification, while the samples from the other cod-end were used for plankton biomass quantification. Sardine eggs from samples of CalVET and CUFES were sorted on board in order to obtain a preliminary data of sardine egg abundance and distribution. In laboratory, the CalVET samples were sorted again in order to remove any remaining eggs and then all sardine eggs were classified into 11 stages of development (Gamulin and Hure, 1955).

R packages of *geofun*, *eggsplore* and *shachar* (ICES, 2006) were used to analyse the data. Daily egg production (P_0) and mortality (z) rates were estimated by fitting an exponential model:

$$E[P] = P_0 \, e^{-Z \, age}$$

The estimate of daily egg production was obtained both using an iterative estimation of mortality (generalised linear model with negative binomial distribution) and multinomial egg ages (Bayesian ageing method, Bernal et al., 2008). The Bayesian ageing method requires a probability function of spawning time.

Results

Hydrology

Sea Surface Temperature and Salinity in the area were ranged from 11.9ºC to 16.9ºC and from 32.50 to 37.03 PSU during the SAREVA0408 survey (figure 1). Colder and lower salinities waters were found in the innermost sector of Bay of Biscay due to the influence of the Gironde River. But warmer and high salinities waters were found off the western coast due to the influence of the Eastern North Atlantic Central Water (sub-tropical origin).

Egg Abundance distribution

A total of 62 transect was surveyed, 54 in Spanish coast and 8 in French coast. Only 4 transect for Cufes and 2 for Calvet (located in the Galician Atlantic coast) did not record positive for sardine eggs. A total of 30950 eggs were caught in 294 from 510 CUFES sampled stations and 4960 eggs in 307 CalVET stations from a total of 530 stations (figures 2 and figure3).

North Atlantic Spanish

A total of 210 CUFES stations from 415 sampled stations were positive for sardine eggs. Along temporal series of this DEPM surveys, sardine distribution area has extended over 200 m upper reaching even the 1000 m depth in the eastern part of the Cantabrian Sea (Figure 2).

Table 1 shows the number of CalVET stations as well as the positive ones. A total of 230 stations were positive over 429 sampled stations (53.61%). A full amount of 3816 sardine eggs were sorted out from the CalVET samples in Spanish coast. Sardine eggs were distributed along the shelf and the larger concentrations were found off the northern coast of Galician (Figure 2) with a maximum value of 9750eggs/ m^2 close to the coast (51 m depth). Most sardine eggs were collected along the Cantabrian Sea and south of the Bay of Biscay. As in previous surveys, very few sardine eggs were found off the western coast of Galicia.

French waters

In this area a total of of 84 from 95 CUFES sampled stations were positive for sardine eggs. A total of 77 stations (76.24%) were positive over 101 sampled stations (Table1). A total of 1144 sardine eggs distributed along the shelf and over 500m depth were collected (Figure2). The highest eggs concentration was located northern to 44.30º on the shelf border.

Daily Egg Production

North Atlantic Spanish waters

The total surveyed area was 48704 km2 and the positive area (spawning area) was estimated in 27149km^2.

The eggs parameters estimates: The daily egg production (P_o) was estimated in 135 eggs/m^2/day (cv: 15%), daily egg mortality rates (z) was -0.016 day^{-1} (cv:21%) and corresponding total egg production (P_{tot})was estimated in 3.7 10^{12} eggs/day (cv: 15%) are shows in Table 1.

The average of sardine eggs by station in positive area was 16.6 eggs/station.
The total egg production in the area by the Multinomial model has been estimated in 3.66 10^{12} egg/day (CV = 15%). By other hand, Traditional (Lo$\hat{o}$s model) and Generalised models have been applied to get total egg production obtaining an egg production of 3.64 10^{12} egg/day (CV = 18.%) and 4.06 10^{12} egg/day (CV = 18.%) respectively.
Table 2 shows time series of sardine total daily egg production based on both the Traditional (Lo$\hat{o}$s model) and the Multinomial methods.

French waters

The sampled area in French waters was 9953 km^2 and the positive spawning area was estimated in 7964 km^2 that represents an 80 % over the sampled area in French waters. The average of sardine eggs by station in positive area was lower (15.1) in French waters than in north Spanish waters (16.6).
The total egg production in the area has been estimated in 1.28 10^{12} (CV=21%) egg/day applying multinomial model (Table1).

In summary, the estimated Total egg production in Spanish waters during SAREVA0408 survey, 3.7 10^{12} (15), is quite similar to estimation in 2005 DEPM SAREVA0405 survey, 3.5 10^{12} (21), but the estimated positive area in SAREVA0408 increased to nearly twice that estimated positive area in SAREVA0405. As result the daily egg production was 134 sardine eggs /m^2 (cv=15) in 2008 and 250 sardine eggs / m^2 (cv=21) in 2005..

Positive area in SAREVA0408 has nearly twice that in SAREVA 0405. Nevertheless, the average of sardine eggs by station in positive area was higher in 2005 (26 eggs/station) than in 2008 (16.6 eggs/station).

Table 2 shows time series of sardine daily egg production based on the traditional Lo$\hat{o}$s method and GAM based estimator. Two methods are comparable and describe a very similar temporal pattern with a successive increase in total egg production from the last two surveys (2005 and 2008).

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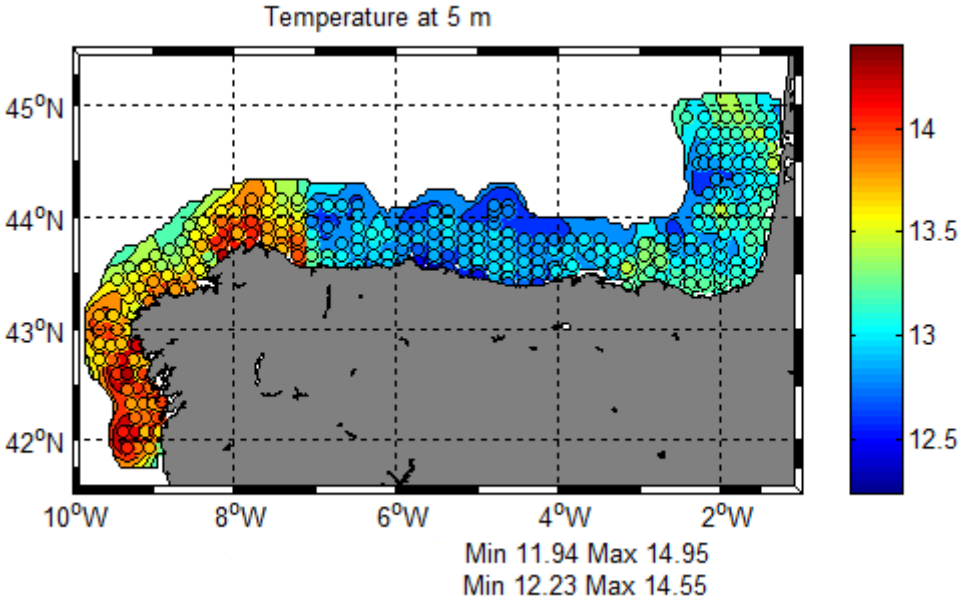

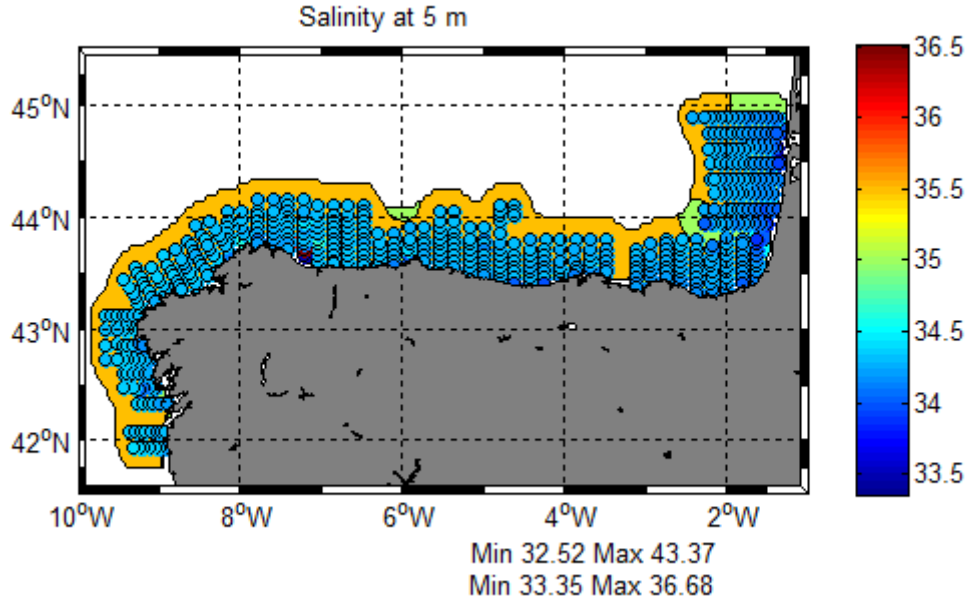

Figure 1. Temperature (ºC) and salinity (PSU) at 5 m depth from CTD Sea Bird 37

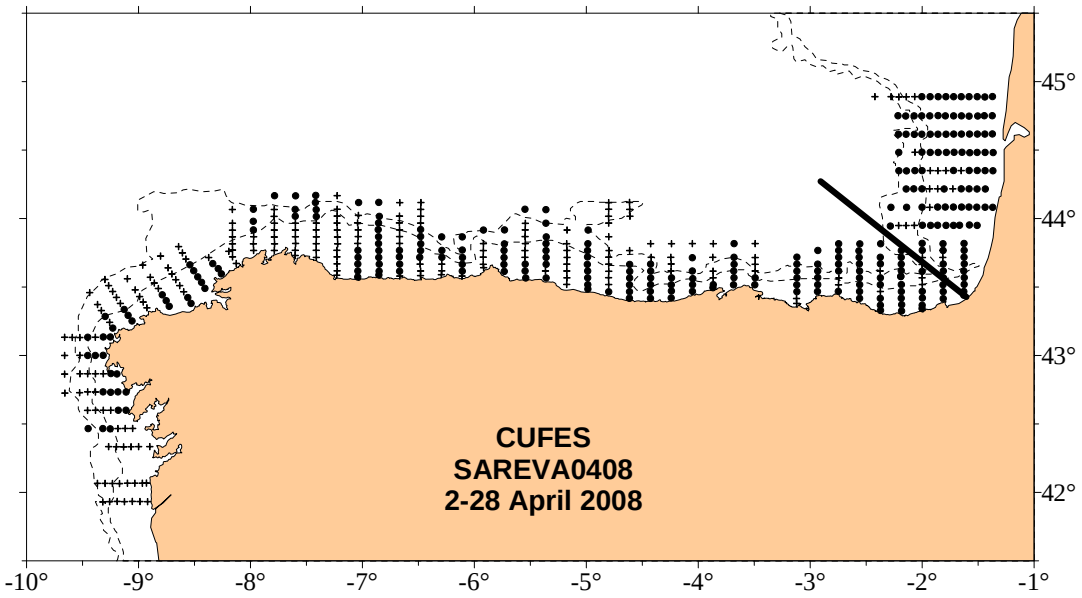

Figure 2. Location of CUFES stations. Presence (ŏ) and absence (+) of sardine eggs. Black line separates North Spanish to French waters.

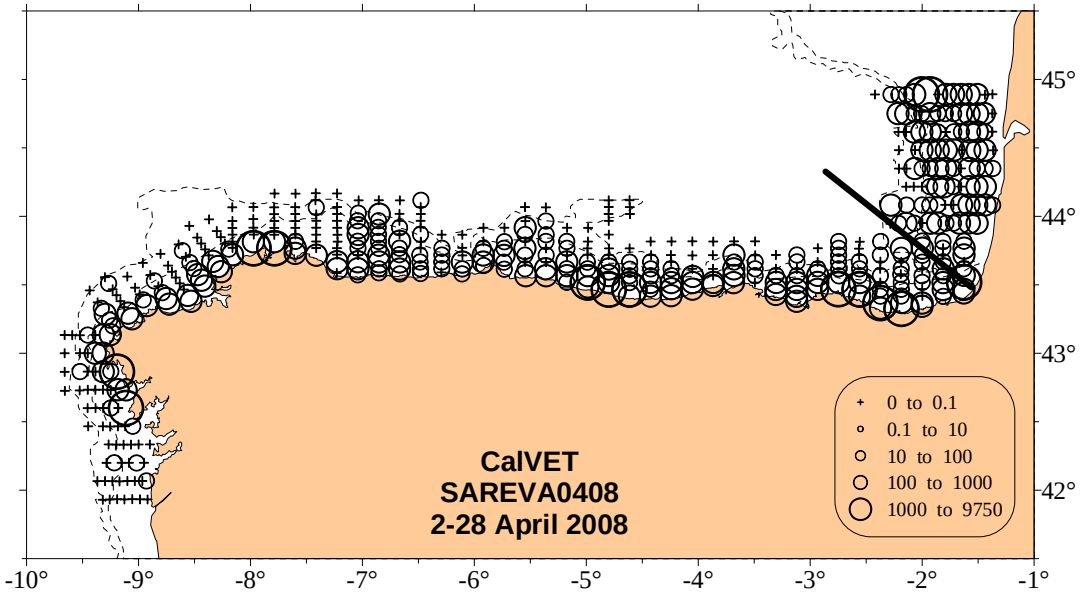

Figure 3. Sardine egg distribution and abundance (eggs/m^2) Black line separates North Spanish to French waters.

Table 1. Results from CalVET sampled in survey SAREVA0408 by region

Parameter	Spanish waters	French waters
Number of sampled stations	429	101
Positive stations	230	77
Sampled area (km^2)	48704	9953
Positive area (km^2)	27149	7964
Total eggs	3816	1144
Eggs/Station in positive area	16.6	15.1

Table 2. Sardine Egg parameters estimates

Parameter	North Spanish waters		French waters	
	Value	CV(%)	Value	CV(%)
P_0 (eggs/m^2/day)	134.9	15	160.6	21
z (h^{-1})	-0.016	21	-0.019	23
P_{tot} (eggs/day)(10^{12})	3.66	15	1.28	21

Table 3. Times series of estimates of sardine daily egg production for north Atlantic Spanish coast, based on the Traditional (Loômodel) and Multinomial based estimator. All estimates refer to 10^{12} eggs day^{-1}.

Year	Traditional model	Multinomial-based
1997	0.72 (82)	
1999	0.34 (44)	
2002	0.52 (33)	
2005	3.20 (21)	3.50 (21)
2008	3.64 (18)	3.66 (15)